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ITEM 5:* STATE OF THE ENVIRONMENT

EMERGING ENVIRONMENTAL ISSUES

Report of the Executive Director

Summary

The present report, in two main parts, is submitted in accordance with the request of the Governing Council contained in its decision 16/16. Part I covers the emerging environmental issues selected for detailed examination: re-use of waste water; volatile organic compounds in air; and tropospheric ozone. Part II comprises a brief update on the issues examined in the report presented to the Governing Council at its sixteenth session (UNEP/GC.16/9/Add.1): new technologies; plastics; municipal wastes; and the ecological situation in the Arctic.

Suggested action by the Governing Council

The Governing Council may wish to take note of the present report of the Executive Director on emerging environmental issues.

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* Refers to the number of the item on the Provisional Agenda (UNEP/GC.17/1).

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I. RE-USE OF WASTE WATER; VOLATILE ORGANIC COMPOUNDS IN AIR; AND TROPOSPHERIC OZONE

A. *Re-use of waste-water*

Introduction

1. Globally, some 3,000 to 4,000 km^3 of freshwater are withdrawn from available sources and used each year. Approximately 69 per cent of this total is used for agriculture, 23 per cent for industry, and 8 per cent for domestic and municipal use.(1) However, water use varies considerably: in Africa and Asia for example, agriculture is the primary user (e.g. Asia uses 86 per cent of its water for agriculture, mainly as irrigation); in Europe, it is industry.

2. In recent decades, withdrawals from freshwater sources for human use have been increasing by about 4 to 8 per cent per year, mostly in the developing world. By the end of the present century, withdrawals for agriculture are expected to increase slightly, and industrial and domestic withdrawals are expected to increase more rapidly, with the latter probably doubling.(2) Even so, agriculture will still be the primary user.

3. Stress on freshwater resources is due, in particular, to smaller volumes being returned to sources than are withdrawn, and to the return of polluted waste-water. Water quality problems, increasing water consumption (especially in the expanding megacities) and the increasing share of industrial water use are some of the reasons why water could become the most critical resource issue in most parts of the world by the late 1990s and the early part of the twenty-first century.

4. The world's supply of fresh water is uneven and often unreliable. Water shortages are already acute in many regions, and are chronic in some areas of East and West Africa, where water scarcity threatens the ability to increase food production to meet population growth.(3) Shortages could reach crisis proportions in the Middle East and North Africa, where the water issue is complicated by political tensions.(2) The severity of water shortages will be further aggravated by a steady deterioration in water quality.

5. The three main sources of waste-water result from agriculture, industry and municipalities.(2,4) About 25 per cent of agricultural water, up to 86 per cent of industrial water, and about 60 per cent of water used for domestic purposes is returned as waste-water.(1) Untreated waste-water from those sources causes serious environmental problems, especially when discharged directly into water bodies. Agricultural waste-water can be rich in nitrates and harmful salts, and can contain fertilizers and pesticides. Industrial waste-water is often polluted and is produced in large quantities. Untreated domestic waste-water, especially when it contains sewage, can carry pathogenic viruses and bacteria and pollutants and, together with unsatisfactory household sanitation practices, has been linked to the high infant mortality rate in developing countries.(5)

6. Re-using waste-water reduces the loading on inland ecosystems, both by decreasing water withdrawals and by effectively decreasing the volume of waste-water that has to be disposed of. Such re-use is a vitally important aspect of water resources management to assist with problems such as water shortages. For example, in the North China Plain, a semi-arid region with a population of about 200 million which includes major cities such as

Beijing and Tianjin, consumption of fresh water by industry, agriculture and the increasing population is outstripping supply. The Chinese State Science and Technology Commission has recommended re-using waste-water as one of several methods to make up for water shortages.(6,7)

7. The Delft Declaration of the UNDP symposium "A Strategy for Water Resources Capacity Building" (June 1991) acknowledges the potential of re-use of waste-water by noting that it is one of the means of reducing demands for and pollution of fresh water.

8. The Dublin Statement of the International Conference on Water and the Environment (January 1992) notes that water re-use could reduce the needs of many industrial consumers by 50 per cent or more, with the additional benefit of reduced pollution. Application of the "polluter pays" principle and realistic water pricing will encourage re-use. The statement adds that increased savings will come from multiple use of water in agriculture, industry and domestic supplies.

9. The United Nations Conference on Environment and Development (UNCED, June 1992) strongly recommended that countries should consider implementing management policies aimed at the re-use and recycling of wastes, applying adequate health safeguards and environmentally sound practices. Chapters 14, 18 and 21 of Agenda 21 outline such policies.

10. Factors leading to successful re-use include the segregation of waste-water for direct use, with appropriate treatment for the remainder, taking into account the source and the intended re-use. Untreated waste-water, as noted above, is often the carrier of organisms and pollutants, depending on its source, and unless it is used carefully or treated, it cannot be widely used. The installation of treatment plants by municipalities and industries has permitted most of the progress in the re-use of waste-water. The treatment process selected depends on factors such as capital and operating costs, required capacity, and the local topography and climate.

11. Many arid and semi-arid countries, where water scarcity is already a serious constraint on further economic development, have realized that treated waste-water is a "new" source of water for productive purposes. Most arid countries of West Asia and North Africa have embarked ambitious programmes for the treatment and re-use of waste-water. Re-use can involve either passing water on from one user to the next, or recirculation within a sector.

Re-use of waste-water for agriculture

12. In Mexico, there is large-scale use of raw sewage (rich in nutrients) for irrigation of public parks and in recreation lakes. However, there is a potential health risk in using untreated sewage in areas where people are present. Mexico's scheme will be monitored closely to assess its technical success and any health risks.

13. Re-use of municipal waste-water for irrigation will usually be more economical than enhanced treatment for drinking water supplies. However, it must be accompanied by appropriate health safeguards; there is the suspicion that crops irrigated with untreated effluent may have contributed to the rapid spread of the 1991 cholera epidemic in Chile.

14. Re-use of treated municipal waste-water in developing countries is mostly for agricultural irrigation. Treated municipal waste-water has been used extensively for many years in Middle Eastern countries to irrigate landscaped areas and fodder crops. In Saudi Arabia, where irrigation and municipal water supplies are the two predominant water users, the limited

groundwater resources and negligible surface water and precipitation led to an early policy decision to re-use all treated municipal waste-water. It is estimated that, of the reclaimed waste water, about 10 per cent will be used in industry, including additional specific pretreatment, and the remainder in agriculture for irrigation(8) a re-use rate in the order of 10 per cent. However, the actual potential for re-use in mixed economies with strong reliance on agriculture may be in the region of 25 per cent. In Israel this target figure has been reached by consistently re-using all water and, for example, rechannelling all sewage discharges into the Mediterranean back into the land, mainly for irrigation of crops and farmland.(8) Israel now re-uses 35 per cent of its municipal waste-water, mainly for irrigation, e.g. of some 15,000 hectares of cotton. Israel's current plans are to re-use 80 per cent of total waste-water flow by the end of the century.

15. There are reports from all over the world that crop yields are significantly increased by irrigation with waste-water that does not contain significant amounts of toxic pollutants, salt, or excessive amounts of nutrient elements. In India, for example, long-term field experiments at the National Environmental Engineering Laboratory in Nagpur have shown that medium-intensity irrigation with waste-water produces higher yields than irrigation with fresh water.(9) It is the nutrients, trace minerals and humus-like organic matter present in waste-water that benefit agriculture.

16. An important secondary effect of waste-water re-use for agriculture lies in the release of high-quality water resources for more demanding purposes, such as industrial processing and domestic consumption.

Re-use of waste-water for aquaculture

17. Another major use of waste-water is for aquaculture. A small fraction of the sewage generated by the seven million inhabitants of Lima, for example, is directed into holding ponds, where bacteria decompose many of the wastes and the solids settle. After 20 to 30 days, the water is fit to raise fish and is also used to irrigate grain crops for cattle.

18. The largest single waste-fed aquaculture system in the world is the Calcutta sewage system in India, where water and sewage are fed into lakes covering about 2,500 hectares. After an initial bloom of algae, fish – principally carp and tilapia – are introduced and additional sewage is fed into the lakes once a month. The system produces about 7000 tonnes of fish annually, which amounts to 2.8 tonnes per hectare per year.(2, 10)

Re-use of waste-water in industry

19. Some countries are making great progress in re-using water in industrial production processes. The high rates of re-use have led to a drastic reduction in industrial demands for water, despite increasing production output figures.(8) The double benefits of environmental improvement and cost-effectiveness have prompted an increase in re-use of water among industries in the developed countries during the last decade. Re-use rates in manufacturing plants in the United States have increased substantially in the last 25 years, and are expected to increase exponentially by the end of the century. Similar trends in manufacturing plants in developing countries would transform the pollution situation, and have a huge impact on future water demand.

20. The potential for industrial re-use of water varies depending on the region, the industry and the quality of water required. In Japan, total industrial water use increased from 50 million m^3 in 1965 to 120 million m^3 in 1974, but by the mid-1970s, two-thirds of the volume came from re-use of water, compared with one-third in 1965.(6) By 1975, industry in the United States had achieved a water re-use rate of 2.2, which indicates that water brought into the plant was used on average 2.2 times before it was discharged. Former West Germany showed similar re-use rate (2.0), as does Japan (1.5).(11)

Re-use of waste-water in domestic supplies

21. Whereas re-use of waste-water is considered for discharge as groundwater only after extensive multi-stage treatment, it is rarely an option for augmenting domestic supplies. Domestic use places the highest demands on water quality; in addition to having a satisfactory taste, odour and appearance, the reclaimed water must be chemically and microbiologically clean. Owing to difficulties in maintaining high quality standards, the drinking of reclaimed water is generally not recommended.(4) In very special circumstances, reclaimed waste-water purified to an exceptionally high standard may be used to supplement a city's drinking water supply. Windhoek (Namibia), was reportedly the first city to add reclaimed water to its public supply, and has been doing so for more than a decade. In 1985, the Texas city of El Paso followed suit.(12) In Tokyo, waste-water is used to flush toilets in high-rise buildings. Recycled water in Japan costs the user less than fresh water.(6)

Barriers to the re-use of waste-water

22. A barrier to the re-use of municipal waste-water is the expense of conventional sewage treatment, such as activated sludge plants or biological filtration. Sewage collection networks are also expensive, often costing many times more than the treatment plant itself. The high cost of these networks is beyond the reach of many countries. Unfortunately, lower-cost alternative treatment approaches, using stabilization ponds, have not become widespread because of the need for large tracts of land, a resource that is not always available in densely populated urban areas. But, where land is available on the edge of a city, the ponds' capacity to produce effluent suitable for crop irrigation is an added attraction. There are also encouraging results from the use of covered, anaerobic ponds, which require less land and provide some degree of treatment.

23. Incomplete knowledge of the health effects of various pollutants remains a barrier to waste-water re-use. It is clear that when untreated waste-water is used to irrigate crops, there is a high risk to health from intestinal nematodes and bacteria. The agricultural or aquacultural use of municipal waste-water can bring the risk of disease when the following occur: an infective dose of a pathogen is present in the field or pond; it reaches a human host; the host becomes infected; and the infection causes disease or further transmission. The treatment of such waste-water is an effective way of safeguarding public health. It is now possible to design and implement schemes for waste-water re-use that pose no risk to public health. Such design requires an understanding of the epidemiology of infections in relation to waste-water re-use. In this way, adequate standards or the microbiological quality of waste-water intended for re-use can be established and public health properly protected.(9) Health protection can be facilitated by other methods, less expensive than treatment of waste-water: crop restriction, with irrigation limited to certain crops and conditions; application waste-water in a way that maximizes protection of health, e.g. irrigation techniques such as

subsurface or drip irrigation, which present waste-water coming into contact with people and agricultural products; and control of human exposure, e.g. by providing suitable clothing, immunization, high standards of hygiene and health education.

24. Lack of information prevents the more widespread re-use of waste-water. The maintenance of good public relations, especially with respect to the protection of consumer health, is a very important task. The public must be confident that schemes re-using waste-water are operated with due regard for health, especially with respect to food produced from agricultural or aquacultural schemes re-using waste-water. In addition, current and potential users would benefit from promotional activities explaining the benefits of re-using waste-water.

25. There are further barriers to the re-use of waste-water. In developing countries, human settlements and industry often have no treatment facilities at all; industrial discharges are largely uncontrolled and water quality is directly affected. In addition, such discharges are growing quickly, often more quickly than waste-water treatment facilities can be provided.(5) In the industrialized world too, not all sewage is processed by treatment plants and, although many industrial discharges are controlled, many are insufficiently controlled or policed. In some countries, standards are still not sufficient to obtain high-quality water.

26. Severe urban pollution, caused by inadequate sanitation and waste-water treatment, inhibits the re-use of river water by downstream users. So, whereas the same water may be abstracted and returned nine times in the course of its journey down the River Thames before reaching London, Bangkok's Metropolitan Waterworks Authority can currently count on each litre being used only once before it becomes unsuitable for further human consumption. Protection of surface water from gross industrial pollution and severely polluting urban runoff could contribute enormously to the conservation and re-use of water resources.

27. Globally, pollution control measures are becoming stricter. Regulations require that contaminants be kept out of the systems whenever possible, that remaining contaminants be properly treated, and that the environment does not become polluted.(4)

Prospects for re-use of water

28. If new projects for the use of waste-water for, say, agriculture and aquaculture are to be introduced or promoted, legislative action may be needed. In many cases existing regulations may be amended, but sometimes new legislation is required. Five areas deserve special attention: creation of new institutions or allocation of new powers to existing bodies to manage schemes; the roles of national and local Governments in the sector with respect to promoting and controlling schemes; right of access to and ownership of wastes, including public regulation of their use; land tenure; and public health protection, including crop restrictions, application methods, occupational health, food, hygiene, etc.

29. Existing schemes may need to be upgraded to improve productivity or reduce health risks. In countries with little or no experience in the re-use of waste-water, pilot projects are advisable; they provide local experience which can be translated into demonstration and other projects.(9)

30. Without realistic water pricing, major water consumers have found it more economic to increase consumption than to introduce conservation or re-

use techniques. Impending water scarcity is forcing a review of such attitudes, and industrialists in particular are actively seeking ways to conserve water, including increasing the degree of re-use of treated waste-water. The economics of waste-water treatment and re-use are therefore closely linked to water pricing and pollution charges. Such economics also depend on the establishment of appropriate standards for the quality of water for different types of use. In the United States, re-use is a sound economic option because of savings in water charges and pollution penalties. Re-use is also encouraged by stringent environmental legislation and enforcement. A number of developing countries (e.g. Brazil, China, Mexico, Turkey), have introduced legislation to control industrial discharges, with varying degrees of success. Others are likely to follow soon.

31. It is important for countries to have policy instruments on re-use of waste-water as well as management directions to encourage and facilitate re-use. Satisfactory legislation measures and proper management practices are needed to ascertain that the policies established for waste-water re-use are followed. Legislation and regulations should have provisions for all financing, planning, construction and operational aspects of waste-water re-use systems, and should establish water quality standards for various uses, protect users, and provide rules for discharge into sewage collection systems. Compliance with effective discharge standards, based on new water protection objectives, would enable successive downstream consumers to re-use water that is, at present too contaminated after the first use. Legislation should also cover priorities and water rights, as well as the sale and distribution of treated waste-water.

32. In the United States, federal water quality laws encourage the re-use of waste-water. A survey in the late 1970s indicated that 536 re-use projects were under way, collectively using about 937 million m^3 of treated waste-water annually: more than 60 per cent for irrigating crops, parks and landscapes; one-third for industrial cooling and processing; and the remainder for recharging groundwater and for various recreational functions.(12)

33. Waste-water re-use has a promising future and, if countries have not already done so, they should start to adopt this practice as a serious alternative to using conventional sources of water. Much could be learned in the years ahead from the pioneering efforts in countries where in water is scarce.

B. *Volatile organic compounds in air*

Introduction

34. The common feature of volatile organic compounds (VOC's) a large group of different substances, is that they contain carbon, hydrogen (and in some cases oxygen and other elements) and they are in gaseous form at ambient temperature. For different groups of VOC's, a number of terms exist in literature, such as hydrocarbons (HC), photochemically reactive organic compounds (ROC), or toxic compounds. In the present report, the VOC methane (CH_4) and the non-methane VOCs (NMVOCs) are discussed separately because methane has unique properties with respect to emission sources, its greenhouse gas effects, its low photochemical reactivity and its relative non-toxicity.

1. *Methane*

35. Methane is a gaseous compound and a natural component of the atmosphere. However, due to increased emissions, the levels of methane in

the atmosphere have increased considerably. From ice-core analyses it has been concluded that methane levels were about 0.75 ppmv (parts per million by volume) in pre-industrial times. In the northern hemisphere, however, methane levels rose to about 1.4 ppmv in the late 1960s and about 1.8 ppmv in mid 1980s.(13)

Methane emission sources

36. Methane is released into the atmosphere by a number of anthropogenic (man-made) and biogenic (natural) activities. It is produced by microbial degradation of organic carbon under oxygen-deficient conditions, e.g. from waterlogged soils, during enteric fermentation in ruminants, in landfill waste dumps, and from waste-water. In addition, methane is the major component of natural gas, and is part of the earth's fossil fuel deposits. Thus, high amounts of methane are released during exploitation and use of fossil fuels. A third major source of methane emissions is the incomplete combustion of fuels, particularly biomass fuels, during which methane is emitted with exhaust gases.

37. Precise quantification of methane emissions is difficult, due to the many uncertainties associated with emission sources. However, it is estimated that global anthropogenic emissions of methane are about 370 million tonnes per year, of which about 30 per cent comes from farm animals (ruminants and animal waste decomposition), another 30 per cent from rice cultivation (microbial activities in water-covered soils), about 20 per cent from coal mining and natural gas releases, 15 per cent from biomass burning, and the remainder from landfills.(14)

38. Natural methane emission sources are even more difficult to quantify: major emissions come from natural wetlands (waterlogged soils, swamps, marshes), fresh water, oceans, and termites. Recent estimates of total biogenic emissions from these sources were 170 million tonnes per year.(15) Of these, natural wetlands are the biggest source of emissions, with about 70 per cent of total emissions.(13)

Methane - environmental effects

39. As a natural compound, methane is relatively non-toxic to human health and ecosysters. However, it is an important greenhouse gas, with an atmospheric lifetime of about 10 years and a global warming potential (GWP) much higher than that of carbon dioxide (CO_2).(16)

40. As a natural trace component, methane is part of the delicate physico-chemical equilibrium of the atmosphere. Elevated levels of methane disturb its stability, for instance, through depletion of hydroxyl radicals in the atmosphere and through increased photochemical ozone production in the troposphere.

Methane emission control

41. One problem in determining methane control options is that most anthropogenic sources of methane emissions are difficult to control. At present there are no feasible technical options for limiting emissions from rice paddies and biomass burning. Technical controls are reportedly possible for limiting emissions from most other sources (e.g. from domestic animals in sheds, coal mining, some natural gas releases, and waste dumps).(14) However, there is little experience with the actual implementation of methane emission control. Therefore, there is no clear indication of the cost-effectiveness and further problems of such control.

2. *Non-methane volatile organic compounds (NMVOCs)*

42. The term Non-methane volatile organic compounds (NMVOCs) refers to all organic compounds that are volatile at ambient temperatures, excluding methane. NMVOCs thus include a very large number of different compounds, ranging from simple molecules such as ethane and ethylene, to complex compounds such as terpenes and chlorinated compounds. For example, more than 250 different NMVOCs have been identified in urban ambient air.(17)

43. NMVOCs are significant air pollutants because they cause photochemical smog formation and several are toxic to human health and ecosystems. NMVOCs have received increased attention in recent years now that sophisticated instruments have become available to monitor them.

44. Concentrations of NMVOCs measured in ambient air are variable. In urban areas, NMVOC concentrations may be in the order of ppbv (parts per billion by volume) for common NMVOC pollutants such as benzene, toluene, or xylene; and in the order of pptv (parts per trillion by volume) for the less common NMVOC pollutants. Because NMVOC monitoring was rare before the last decade, there are insufficient data about trends of NMVOC concentrations in urban and rural areas. However, it is generally believed that urban NMVOC levels have increased with growing traffic and industrialization.

NMVOC emission sources

45. NMVOC emissions come from both anthropogenic and biogenic sources. The composition and effects of NMVOCs released from various sources are difficult to determine. Reliable quantitative data about NMVOC emissions are rare. Existing emission inventories are not always reliable, because inventory methods are not standardized, many different emission sources have to be included, and there are large amounts of diffuse emissions which are difficult to quantify.

46. The major anthropogenic sources are: incomplete combustion processes; the evaporation of solvents and gasoline; and industrial processes. NMVOC emissions from incomplete combustion processes are released with exhaust gases. The amount of NMVOCs emitted depends on the efficiency of burners, and on the fuel type used. Large industrial boilers are usually very efficient and have low NMVOC emissions. However, inefficient small domestic stoves and motor vehicle engines release high amounts of NMVOCs. Open burning of vegetation, solid wastes and other biomass also results in high NMVOC emissions.

47. Evaporative NMVOC emissions result from domestic and industrial use of solvents. The various sources are not known in detail, and the emission densities of single sources can vary significantly. Solvents evaporate easily, so it can be assumed that most solvents are finally emitted into the air. Further significant NMVOC evaporation results from the loss of motor vehicle gasoline during storage, distribution, fuelling, and driving. The amount of evaporation depends on the type of gasoline, the ambient temperature and the design of storage tanks.

48. The major sources of NMVOC emissions from industrial processes occur in the oil and gas, mining, petroleum, petrochemical, chemical, plastic, rubber and food industries.

49. Global anthropogenic NMVOC emissions are estimated at about 120 million tonnes per year.(18) On a global average, incomplete combustion of firewood is the largest single source, contributing about 20 per cent of total emissions. Open burning of grasslands and savannas contributes about 16 per cent and another 16 per cent is estimated to come from the transportation sector, including gasoline combustion and evaporation.(18)

50. The contribution of various sources to total anthropogenic emissions depends on the economic situation of a country or a region. In highly developed countries and urban areas, motor vehicle traffic and industrial processes play a dominant role in NMVOC emissions. For example, motor vehicle traffic contributes 30 to 50 per cent of NMVOC emissions in some industrialized countries.(2) In developing countries and rural areas, small domestic sources and biomass burning are believed to be more important sources.

51. Natural NMVOCs emissions occur from vegetation (through leaves), particularly forests, natural gas seepage, oceans, and the incomplete combustion in natural fires. The amount of global natural NMVOC emissions is unknown. In the United States, it has been estimated that natural NMVOC emissions are about 2 to 4 times higher than anthropogenic ones.(19) Thus, it can be assumed that global natural NMVOC emissions might be in the range of 240 to 480 million tonnes per year.

NMVOCs - environmental effects

52. The environmental effects of NMVOCs depend mainly on their individual properties. As a group, NMVOCs can have major adverse effects with respect to photochemical smog and ozone formation, and may be toxic to humans and vegetation. Furthermore, various NMVOCs contribute to other environmental problems such as depletion of the stratospheric ozone layer and, with persistent organic chlorinated compounds, contribute to the long-term pollution of ecosystems.

53. Photochemical smog is formed in the lower atmosphere from nitrogen oxides (NO_x) and NMVOCs in the presence of sunlight. Ozone is the main component of photochemical smog. In the undisturbed atmosphere there is equilibrium between the build-up and destruction of ozone, depending on the meteorological and chemical parameters of the atmosphere. Photochemically reactive NMVOCs influence this equilibrium and can lead to enhanced ozone production. Background ozone levels at the turn of the century are estimated at around 10 to 20 ppbv.(20) Today, background levels in Europe and North America are estimated at 20 to 40 ppbv, and in some urban areas may regularly exceed 100 to 200 ppbv.(21) Some NMVOCs react very quickly - producing ozone quickly. Others react slowly, resulting in maximum ozone production downwind from the NMVOC emission sources.

54. Ozone is a powerful oxidant and damages living cells. Even at low levels, ozone can damage human lung tissue; its effects on human health can result in asthma attacks and increased susceptibility to lung infections.(22) Ozone also damages vegetation, causing crop losses.

55. A number of NMVOCs are directly toxic to human health, and some of them are carcinogenic. Fortunately, emissions of toxic NMVOCs are rather small compared to overall NMVOC emissions. Nevertheless, there can be considerable risk to human health in the vicinity of emission sources. Benzene and vinyl chloride have been proven to be carcinogenic; acrylonitrile and formaldehyde are classified as probable carcinogens.(22) There is no safe guideline value with respect to carcinogenic compounds. While vinyl chloride and acrylonitrile emissions are limited to certain industrial processes (such as in the chemical and plastics industries) there are a variety of major sources of benzene and formaldehyde emissions. Formaldehyde is a major component of all incomplete combustion processes. In many urban areas, benzene, is considered to be one of the major causes of leukaemia,(23) is emitted in high concentrations in motor vehicle exhaust and through gasoline evaporation.

56. Non-carcinogenic NMVOCs with considerable direct toxicity include styrene, toluene, and various chlorinated compounds. Toxic effects include eye irritation, damage to the central nervous system (fatigue, confusion, lack of coordination), and damage to the mucous membranes (coughing, tightness of the chest).

57. Several NMVOCs are directly toxic to vegetation. Ethene, which is emitted by motor vehicle exhausts and by small domestic sources of combustion, is about eight times more toxic to vegetation than SO_2. Formaldehyde, which is mainly emitted from firewood combustion, is three times more toxic to vegetation than SO_2. However, the direct toxicity of both ethene and formaldehyde is thought to be much less damaging to vegetation than the phytotoxicity of the ozone produced during the photochemical reaction of NMVOCs.(24)

58. Some volatile chlorinated compounds, such as tetrachloromethane (used, for example, as a solvent in the metal industries), have a long atmospheric lifetime and cause depletion of the stratospheric ozone layer. Before they break down, such stable substances may reach the upper part of the atmosphere, where, under certain physico-chemical conditions, one single atom of chlorine may cause the destruction of up to 100,000 molecules of ozone. Other volatile chlorinated compounds in the air (such as 1,1,1-trichloroethane, used as an industrial and domestic solvent) can be deposited on soils and surface waters. Because of their chemical stability they may accumulate in the various components and organisms of ecosystems and pose a long-term threat.

NMVOC emissions control

59. To reduce ozone levels, reductions of NMVOC emissions are more effective than reductions of nitrogen oxides. A number of control technologies for NMVOC emission sources have been developed and implemented in many industrialized countries.

60. NMVOC emissions from domestic, incomplete combustion can be controlled by a combination of suitable fuels and stoves. Improved efficiency not only cuts NMVOC emissions, but also leads to considerable fuel savings. The development of appropriate small fuelwood stoves remains a challenge for the environmentally sound development of many countries.

61. NMVOC emissions from motor vehicles can be controlled by modifying the composition and properties of motor fuels and improving combustion processes and post-combustion cleaning devices. In several countries, the concentration of the carcinogenic compound benzene in gasoline has been reduced to 1 per cent or less. Three-way catalytic converters, which remove 90 per cent of NMVOC emissions, have been introduced in Europe, Japan and the United States, and other areas. An important additional step in reducing emissions from an existing motor vehicle fleet lies in regular inspection and maintenance. However, regardless of improvements in fuels and controls, emission levels will not improve if increasing traffic congestion makes travel by vehicle less efficient. Better traffic management will play an important part in preserving technology-based emission reductions.

62. NMVOC emissions from industrial processes can be controlled through improved process design and post-process NMVOC combustion. Recovery or thermal use of NMVOCs released in industrial processes means that NMVOC control can even bring profits for industry.(25)

63. NMVOC emissions from solvent evaporation can be controlled through solvent recovery. However, the most cost-effective method of reducing such emissions is to substitute NMVOC-based solvents with water-based solvents.

64. NMVOC emissions from evaporation of gasoline can be reduced by using a less volatile gasoline formula. Secondary control devices which have been introduced in several countries include special carbon canisters (which absorb evaporating gasoline) as part of a vehicle's fuel venting system.

65. In November 1991, a protocol on reducing NMVOCs was added to the United Nations Convention on Long-Range Transboundary Air Pollution, which commits the 23 signatory countries to reducing their emissions of NMVOCs by at least 30 per cent by the year 1999. Some ccuntries have shown their intention to reduce NMVOC emissions by 50 per cent by the year 1999.(2)

C. *Tropospheric ozone*

Introduction

66. About 90 per cent of total ozone is present in the stratosphere (15 to 50 km from the surface of the earth) with the remainder in the troposphere (the lowest layer of the atmosphere extending up to 15 km above the earth's surface). Stratospheric ozone acts as a protective shield absorbing harmful ultraviolet radiation. Ozone in the troposphere, however, is a noxious pollutant damaging vegetation, materials and human health. Near the surface, tropospheric ozone is involved in the complicated series of chemical reactions that produce the photochemical smog that has become a major problem in many cities of the world. Ozone is also a greenhouse gas which may have important climatic consequences.

67. Measurements of ozone levels over the past few decades show that, as yet, there has been no significant change in the average total amount of ozone over the whole globe. However, there are indications of significant regional changes, with ozone decreasing with altitude and increasing lower in the troposphere.

68. There are no significant direct anthropogenic emissions of ozone. Although some ozone can be present in the troposphere due to downward mixing of stratospheric ozone, most tropospheric ozone is formed as a result of photochemical reactions (triggered by sunlight) when precursor chemicals such as nitrogen oxides (NO_x), carbon monoxide, oxygen and volatile organic compounds are available. These precursor chemicals result from anthropogenic emissions, mainly from fossil-fuel-fired power stations, industrial processes, refineries, vehicle exhausts and the evaporation of solvents and fuels.

69. Due to the action of sunlight, peak ozone concentrations usually occur in the late afternoon (19), and may last up to 12 hours before diminishing overnight, when ozone is destroyed by nitric oxide (NO) and surface deposition.(26, 23)

70. Pollution from surface ozone (i.e. tropospheric ozone at ground level) is systematically monitored by a few countries, mainly in urban locations. The distribution of ozone in the entire troposphere is monitored by a dozen of the ozone sonde stations of the World Meteorological Organization's Global Ozone Observing System (GOOS). Data from Europe, Canada and Japan generally indicate that tropospheric ozone concentrations are increasing. However, the ozone concentration varies markedly with latitude, altitude, season and availability of precursors.(15) During the past two to three decades, concentrations have increased by 20 to 50 per cent at middle and high latitudes in the northern

hemisphere where the current increase is 1 to 2 per cent per year.(19, 6, 11, 27). However, either no trends or decreasing trends have been detected in some parts of the southern hemisphere (e.g. New Zealand).(28)

71. During 1979 to 1985, 20 ozone monitoring stations in Canada reported annual mean ozone levels above the Canadian standard of 15 parts per billion (ppbv). Although a 242-site network in the United States reported a 13 per cent decline in peak ozone levels during 1979 to 1986, ozone levels still exceed the United States ozone standard at 5 to 10 sites every day; and in 1986 more than 75 million Americans lived in areas where the national ozone standard was exceeded. In the Los Angeles basin, peak levels of ozone are nearly three times higher than national standards. That area has 12 million people, 8 million vehicles and 40,000 sources of industrial pollution.

72. Although disputed by some scientists, European data indicate that concentrations of ground-level ozone have more than doubled over the continent in the past 100 years. During the past 20 years, surface ozone concentrations have increased in Finland, Germany, Italy, the Netherlands and Sweden. In all these countries, NO_x emissions have also increased.

73. A recent World Health Organization (WHO)/UNEP report on urban air pollution in the world's megacities reported high ozone levels in Los Angeles, Mexico City and Tokyo, where, on certain days of the year in 1988, national air quality standards were exceeded by 50, 70 and 12 per cent respectively. Beijing, Jakarta and New York exceeded the WHO hourly guideline value at times, but Bangkok, London and Seoul normally remained within it.(21)

74. Long-range transports of precursors cause ozone to be produced far from the emission sources. On days favouring photochemical activity, polluted air masses from urban and industrial areas can enhance ozone levels in suburban and rural areas several hours downwind. Indeed, ozone production may only become significant 10 km downwind from the sources of precursor emissions, while maximum ozone concentrations may not be attained until 40 to 60 km downwind because of the time taken to produce ozone.(19) An increase in precursor emissions in cities results in increased concentrations of ozone downwind. The precursors also originate in tropical regions, where there is extensive biomass burning.

75. During the annual season of forest and savannah fires, increased concentrations of tropospheric ozone have been detected over central Brazil, Namibia, South Africa and Zaire. Satellite information also indicates some increase over the southern Atlantic, downwind from those regions. The ozone appears to be related to the burning of forests in Amazona and the savannah grasslands of Africa (29), which releases trace gases such as CO, NO_x and hydrocarbons which, through the action of sunlight, lead to the formation of ozone in the troposphere.

Effects on vegetation

76. Ozone can damage cells in the leaves of many tree and crop species, interfering with photosynthesis and resulting in reduced growth. Ozone-damaged trees are highly susceptible to drought, insect attack and root rot.(6) When there is abundant ozone in the presence of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2), vegetation is even more susceptible to damage. Studies in the United States conclude that SO_2 may increase the sensitivity of plants to leaf injury by ozone. Exposure to those chemicals, in combination with acid rain, mist and fog, can break down cuticular protective wax and allow nutrients to be leached out, resulting in plant nutrient deficiency. The United Nations Economic Commission for

Europe (ECE) within the framework of the Convention on Long-Range Transboundary Air Pollution, has determined critical levels at which various pollutants cause significant inhibition of growth.

77. During some years, average ozone concentrations in the eastern United States are high enough to reduce yields of soya beans and cotton by about 7 per cent, and alfafa by more than 30 per cent.(6, 30) Repeated ozone peaks have damaged the white pine in Canada and the eastern United States, and reduced growth rates of red spruce at high elevations in the Appalachian Mountains.(31)

78. The United States National Crop Loss Assessment Network (NCLAN) estimated that in 1980 ozone damage to crops in the country amounted to $1 to 5 billion a year. NCLAN also determined that a 25 per cent reduction in current ozone levels throughout North America could result in a benefit of $1.6 to 1.9 billion each year. Conversely, a 25 per cent increase in ambient ozone concentrations would cost $1.9 to 2.3 billion a year in lost production, in 1980 dollars.(11)

Effects on materials

79. Tropospheric ozone destroys many structures and materials (32), for example, relatively low levels of ozone cause stretched rubber to crack. Ozone also attacks cellulose in textiles - including acetate, nylon, polyester and cotton - reducing their strength and fading fabrics and dyes. Ozone may also damage antiquities, even inside museums and art galleries.(19, 33)

Effects on human health

80. Ozone levels averaging more than 0.10 ppmv (200 $\mu g/m^3$) over a period of one hour can cause health problems. Ozone irritates the eyes and mucous membranes of the respiratory system, causes coughing and choking, reduces resistance to colds and pneumonia, and can aggravate chronic heart disease, asthma, bronchitis and emphysema.(6, 34)

81. Surface ozone is the main component of smog.(19, 35) Smogs first appeared in Los Angeles in 1949, and became a problem in London and over much of California during the 1950s. In the 1960s, they were recognized as a nation-wide problem, and in the 1970s were experienced in large cities in Australia, Europe and Japan.(19, 6)

82. In a health survey conducted during a severe smog episode in the Los Angeles basin during September 1979, 83 per cent of people questioned reported discomfort or concern for their health. Fifty-seven per cent complained of burning or irritation of the eyes, and 25 per cent reported headaches, breathing irritation, sore throats or stuffy noses. Hospitals reported increases of up to 50 per cent in the number of patients admitted with chronic lung diseases, such as emphysema and asthma.

83. An assessment of the health effects of ozone and particulate matter suggests that all 12 million residents of the South Coast Air Basin of California experience ozone-related symptoms on an average of up to 17 days each year. Attaining air pollution standards could save 1,600 lives a year in the region.(36)

84. Smog is now a world-wide problem. High-latitude areas, in the northern hemisphere, such as Scandinavia, are frequently receptors for oxidants and their precursors, transported from distant sources. Large-scale smog episodes now occur frequently in Europe, but they are still not as frequent as in the United States.(19) One dilemma facing pollution control agencies is the relative degree of control to be placed on sources of smog precursors. However, control programmes are either in place or are being negotiated in Europe, Japan and North America.(1)

85. Cities in many developing countries also suffer from high ozone levels and as the number of vehicles in these cities continues to rise, both NO_x and VOC concentrations are likely to climb in the years ahead unless emission controls are applied. Furthermore, many of these cities are located in hot and sunny climates that favour ozone formation, with the potential to increase the severity of the smog problem in developing countries (37).

86. Surface ozone levels are generally high throughout much of the industrialized world, and the WHO recommended maximum hourly levels of 100 to 200 $\mu g/m^3$ of ambient air are exceeded regularly, even in relatively remote clean-air regions.(11) In Europe, both VOCs and NO_x must be reduced by an estimated 75 per cent of current levels to ensure the health of local ecosystems. Such a radical cut in precursor emissions should be considered by all Governments.

87. Several international organizations such as WHO, ECE and the European Community have proposed or set guideline values for the protection of human health and/or vegetation which indicate levels, combined with exposure times, at which no adverse effects are expected from surface ozone. The ECE is considering the introduction of the "excess ozone" parameter as a measure to assess potential vegetation damage. In general terms, excess ozone is defined as the sum, over all hours in a given period, of all concentrations in excess of a given limit. However, it is not yet certain at what level the guideline value has to be set and which interval of time during the day should be selected as being representative for "active" plants.

Global surface warming

88. Ozone plays a number of important roles in both the troposphere and stratosphere in regulating the earth's temperature. Like carbon dioxide, ozone is a greenhouse gas. Tropospheric ozone is a major absorber of long-wave, infra-red radiation. If its concentration in the troposphere were to increase, more of the earth's infra-red radiation would be absorbed before being lost in space, contributing to radiative heating of the earth's surface. However, the ozone concentration varies with altitude, latitude and season, because it is produced photochemically and has a lifetime of, at most, several weeks. Distributions and trends are not yet adequately documented. (16, 17)

89. Tropospheric ozone increases in the northern hemisphere ranging from 7 to 20 per cent per decade during the past two decades, are considered to have added to global surface warming comparable to the contribution by the other greenhouse gases.(38) Most data show an increase of about one per cent per year for ozone below 8 km altitude in the northern hemisphere, but not in the southern hemisphere. Although it is likely to be extremely important, at the present stage it is not possible to quantify the current contribution of tropospheric ozone to global greenhouse radiative forcing. However, it has been calculated that a 10 per cent, uniform global increase would increase radiative forcing by about one-tenth of a watt per square meter.(16, 17) This effect of an anthropogenically-induced tropospheric ozone increase on climate change deserves special attention.(38)

II. UPDATE ON NEW TECHNOLOGIES; PLASTICS; LIQUID MUNICIPAL WASTES; AND THE ECOLOGICAL SITUATION IN THE ARCTIC.

90. The issues of new technologies, plastics, municipal wastes and the ecological situation in the arctic were discussed in the Executive Director's report to the Governing Council at its sixteenth session (UNEP/GC.16/9/Add.1). The present report updates that earlier report.

A. *New Technologies*

91. Perhaps the greatest environmental threats come from modern biotechnology based on recombinant DNA techniques which are finding applications in many sectors in industry and agriculture. Biotechnology was discussed at UNCED. Programme areas in Agenda 21 in relation to environmentally sound management of biotechnology include: increasing the availability of food, feed and renewable raw materials; improving human health; and enhancing safety, international cooperation and mechanisms for the environmentally sound application of biotechnology. Technologies for biodiversity conservation and sustainable use of its components as well as the use and handling of modified living organisms resulting from biotechnology were a focus in negotiating the Convention on Biological Diversity, and are reflected in various of its articles.

92. Other new technologies with implications for the environment currently being developed include:

- Technologies for use in the fight against desertification in the world's productive drylands; technologies for irrigated agriculture, e.g. drip irrigation, efficient closed horizontal and vertical drainage, re-use of drainage water after desalination, new and improved water desalination techniques (reverse osmosis, cation exchange, etc), new energy sources for water desalination, chemical/biological cleaning of underground drainage facilities, etc; and techniques for stabilizing soils and conserving runoff water;

- CO_2-related technologies, e.g. removing CO_2 from industrial emissions; re-use of CO_2 for synthesis of chemicals such as methanol; deep-sea storage of liquified CO_2;

- New energy sources, such as solar cells for houses and cars, fuel cells, marine temperature power generation;

- New automobile technology, e.g. developments in lean-burn engines, electric cars, hydrogen-engined cars, methanol-driven cars, liquified-natural-gas driven cars and solar-cell cars;

- Waste-related technology, comprising recycling and re-use.

93. Many of the technologies listed in paragraph 92 above represent advances in component design allowing the greatest environmental improvement in the long term. However, government and economic policies have to encourage the adoption of the advances, or cease to favour the continued use of older, inefficient technologies. The adoption of new industrial technologies has, in particular, important environmental ramifications. In addition, information, organization and policy are often as important as the availability of new technologies.

94. Agenda 21 notes that new and efficient technologies will be essential to increase capabilities (in particular those of developing countries) to achieve sustainable development, sustain the world's economy, protect the environment, and alleviate poverty and human suffering. Inherent in such a pursuit is the need to address the improvement of technology currently used and replace it when appropriate, with more accessible and more environmentally sound technology.

95. Awareness of the connection between technology and the environment continues to stimulate programmes and activities to promote and develop cleaner technologies. However, although agencies and institutions are spending more time on the complex aspect of assessing the environmental consequences of new technologies, technological and scientific developments are being pursued without adequate consideration for their environmental implications. With proper technology assessment and in-depth consideration of environmental impacts, the adverse effects of introducing new technologies would be greatly reduced or avoided altogether.

96. There is a large gap between the scientific and technological research pursued world-wide and the level of efforts to assess its environmental consequences. OECD data show that some 300 billion European Currency Units (ECUs) are spent on scientific and technological developments; in comparison, only some 10 to 20 million ECUs are spent on assessing the environmental impact of new technologies.(39) In addition, assessments of environmental consequences usually take place when new technologies have reached a pre-commercial or early commercial stage. Sometimes this is too late. Environmental information needs to be available before technologies reach the market and adverse effects on the environment materialize, since, once important investments are already committed to a technology, it becomes very difficult and costly to change course.(39)

97. At the time of compiling the present report, the United Nations Department of Economic and Social Affairs was organizing an international expert group meeting on technology assessment, monitoring and forecasting, to be held from 25 to 28 January in Paris. The meeting is expected to articulate methodologies and practices for economic, social and environmental impact assessment - factors that foster capacities for technology assessment and forecasting.

B. *Plastics*

98. Plastics have many advantages and with the exception of their disposal, are quite environmentally sound. To help ameliorate the disadvantages, several options could be considered. Where better materials than plastics are available, their use could be encouraged. Where uses of plastics are not essential and are unnecessarily damaging, substitutes could be encouraged. Where pollution is the result of disposal by careless users, such users need to be controlled.

99. The percentage of plastic in solid wastes has been increasing steadily, and solid wastes containing non-biodegradable plastics often cause damage to and difficulties in operating municipal solid-waste incinerators. The plastics content of solid waste in the United States is expected to reach 10 per cent by the year 2000, thus making plastics a candidate for recycling.(1) However, plastic wastes are highly heterogeneous and difficult to identify for sorting. Some have been successfully recycled and attempts to recycle others continue. In the United Kingdom, for example, about 50,000 tonnes of polyethylene film – some 10 per cent of total production – are recovered every year to provide useful and serviceable goods, such as certain types of builders' sheeting and black refuse bags. Some car manufacturers using large quantities of plastics have adopted the practice of labelling plastic parts, thus facilitating the sorting process for recycling.

100. Considerable research is under way to find better ways to recycle plastics. However, enough useful options already exist. Although there is progress in the field of recycling (e.g. stamping plastic packaging as "recyclable" to make sorting easier, establishing collection points for packaging and other plastic wastes), recycling is not as widespread as it should be. There is still a need to market recycling better and increase the willingness to practise it.

101. Continued work on plastics disposal includes advances in developing degradable plastics, which disintegrate once their useful life is over e.g. when exposed to sunlight, bacteria or certain chemicals in water. Chemically degradable plastics are currently being developed. They are used, for example, as temporary protective coatings for high-value goods such as cars, and dissolve in water when treated with acid or alkali. A potential problem with recycling degradable plastics is that their lifetime is unknown, and so their increased application could complicate an already difficult sorting problem.

C. *Liquid municipal wastes*

102. As municipal water use increases, so does the quantity of waste-water produced. A major difficulty is that investment to improve sanitation (e.g. waste-water treatment and disposal systems) lags far behind investment in water supply. The result is that ever greater quantities of untreated waste-water are now discharged in municipal areas, exposing urban populations to health risks, particularly when faecal matter is present. The gains from improved water supply in terms of health and hygiene are diminished as growing populations, particularly in developing countries, are exposed to the risks from highly polluted waste-water and urban runoff. The introduction of available and appropriate technologies and the construction of sewage treatment facilities could bring significant improvements to protect the environment and improve health.

103. The costs of facilities for treating waste-water and sewage have continued to escalate. Unfortunately, lower-cost alternative treatment, based on stabilization ponds, has not become widespread because of the need for large tracts of land that are not always available in densely populated urban areas. However, there are encouraging results from the use of covered, anaerobic ponds, which require much less land and provide some degree of treatment.

104. The New Delhi Statement of the Global Consultation on Safe Water and Sanitation in the 1990s (September 1990) declares that access to sanitation facilities is a crucial component of social and economic development. Services for the management of water resources and liquid wastes can be extended with low cost and appropriate technologies and political commitment. The Delft Declaration (June 1991) states that, to cope with increasing populations, water resources must be protected and capacities need to be built up to correct institutional weaknesses and malfunctions and thereby improve local provision of water services. Country-specific strategies are needed. The Dublin Statement (January 1992) recognises the basic right of all humans to have access to clean water and sanitation. It enlarges on the issues of community involvement, capacity building and appropriate water pricing to curtail waste and pollution.

105. In June 1992, UNCED considered the problems of managing liquid wastes and recommended a wide variety of actions for national Governments and international organizations to ensure the environmentally sound management of such wastes. The recommendations are contained in Agenda 21, Chapter 21. The actions cover waste minimization; maximization of safe waste re-use and recycling; promotion of environmentally sound waste disposal and treatment; and extending waste service coverage.

D. *The ecological situation in the Arctic*

106. As reported to the Governing Council at its sixteenth session, (UNEP/GC.16/9/Add.1), the ecological situation in the Arctic is unique due to the very specialized Arctic flora and fauna (including the importance of lichens); the refuge it provides for species decimated in other parts of the world; its rich fishing grounds; its reserves of gas, oil and minerals; and the long time it takes for the environment to recover from damage. As reported, the process of protecting the Arctic is under way. The eight Arctic countries - Canada, Denmark, Finland, Iceland, Norway, Sweden, the United States and the Russian Federation - are taking action in the fields of conservation of Arctic fauna and flora; protection of the Arctic marine environment; emergency preparedness and response in the Arctic; and Arctic monitoring and assessment.

107. In order to present and address issues pertaining to further international cooperation among the Arctic countries, an intergovernmental ministerial-level conference on Protection of the Arctic Environment was held in Rovaniemi, (Finland), in June 1991. The eight Arctic countries were invited to adopt the Arctic Environmental Protection Strategy and the Ministerial Declaration for future work.(40)

108. *The State of the Arctic Environment Reports*, consisting of six specific State-of-the-environment reports prepared by Arctic countries, was published in 1991, covering acidification, heavy metals, underwater noise, oil pollution, organochlorines and radioactivity in the Arctic region. The reports will have to be updated regularly for evaluation by the eight Arctic countries.(41)

109. In September 1992, cooperation to protect the sub-Arctic environment of northern Europe was extended to include the northern parts of Sweden and Finland, which, together with Norway, the Barents Sea area and the districts of Murmansk (Kola) and Arkhangelsk (White Sea and Kara Sea areas), form the so-called Barents region. Barents region environmental cooperation was set out in a Nordic-Russian Ministerial Declaration at Kirkenes (Norway) in September 1992.

110. In January 1993, foreign Ministers from the Russian Federation and Nordic countries set up the Barents Euro-Arctic Council to revive the cooperation in the Arctic region that had been interrupted by the Cold War. The Council will be a forum for ministers to discuss problems ranging from cleaning the environment to promoting investment in industry and attracting tourists. The Council will discuss, for example, dumping of nuclear waste in the Arctic seas; opening the northern sea route for a commercial shipping short-cut between Asia and Europe; and tapping oil and gas in the Barents Sea area.

111. Since 1990, reports have come to light on the possible dumping of radioactive materials, including reactor cores, in the Barents and Kara Seas. A Russian Federation-Norwegian investigation began in August 1992, with the participation of the International Atomic Energy Agency (IAEA) Marine Environment Laboratory, Monaco. Preliminary results were presented by the delegations of Norway and the Russian Federation at the 15th Meeting of the Contracting Parties to the London Dumping Convention in November 1992. A joint Norwegian-Russian Federation follow-up expedition to the Kara Sea to carry out investigations at dumping sites is currently planned for the Arctic summer season in 1993.

112. An advisory group meeting on "Assessment of the Actual and Potential Consequences of the Dumping of Radioactive Waste into the Arctic Seas" is scheduled for 1 to 5 February 1993 in Oslo. The meeting organized by the IAEA, in cooperation with the Norwegian-Russian Federation expert group, will be attended by international experts in the field.(42) It aims to start a project to address international concern over the alleged dumping and to coordinate future efforts to assess present and future impacts.

113. During 1992, ozone in the atmosphere over the Arctic and much of Europe was found to be thinning in winter by up to 20 per cent. No ozone hole similar to that of the Antarctic has appeared over the Arctic, but seasonal depletions are expected to continue. The possible causes of this unprecedented destruction of ozone might include the continuing accumulation in the upper atmosphere of chemicals that destroy ozone; volcanic particles from the eruption of Mt Pinatubo which could soak up natural nitrogen compounds in the stratosphere that normally react with chlorine compounds and prevent them destroying ozone, however the role of Mt Pinatubo in ozone destruction over the Arctic is not clear; and the formation of a large high-pressure system over Europe and the North Atlantic during December 1991 and January 1992, which caused weather systems of the lower atmosphere to swell upwards into the stratosphere, effectively reducing the thickness of the ozone.(43)

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